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Annis et al.

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(54) **CABLE ASSEMBLY**

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(51) **Int. Cl.**

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H01R 13/502	(2006.01)
H01R 13/52	(2006.01)

(52) **U.S. Cl.**
CPC ***H01R 13/426*** (2013.01); ***H01R 13/502*** (2013.01); ***H01R 13/5208*** (2013.01)

(58) **Field of Classification Search**
CPC .. H01R 13/412; H01R 13/428; H01R 13/434; H01R 33/0845
USPC 439/744, 745
See application file for complete search history.

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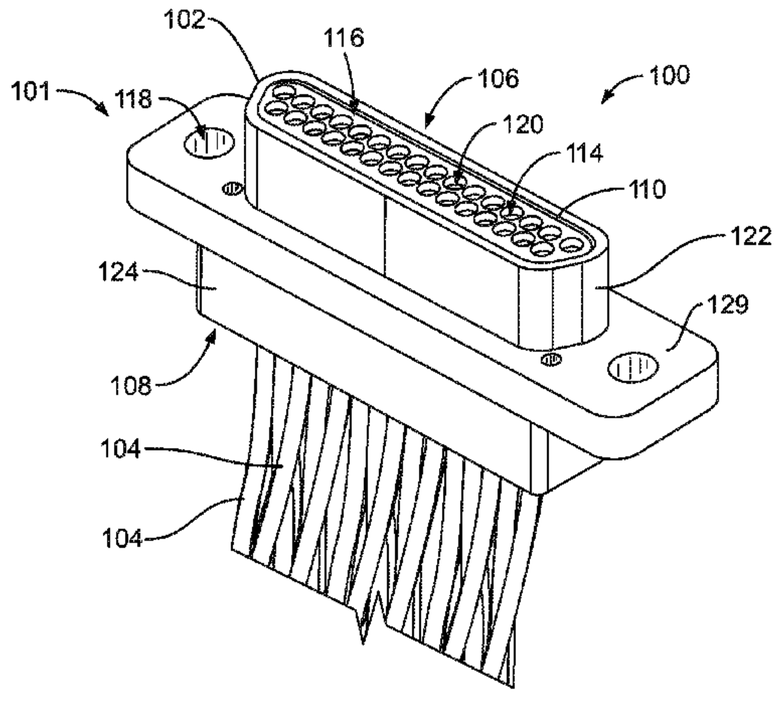
Primary Examiner — Phuong Dinh

(57) **ABSTRACT**

A connector for a cable assembly includes a shell, a contact housing, and multiple finger clips. The contact housing is held in a chamber of the shell. The contact housing defines contact cavities extending through the contact housing between front and rear ends thereof. The finger clips are held in the contact cavities. The finger clips have deflectable latches. The contact cavities of the contact housing are configured to removably receive electrical contacts therein through the rear end. The deflectable latch of the finger clip in the corresponding contact cavity is configured to engage a retention shoulder of the electrical contact to removably secure the electrical contact in the contact cavity. The electrical contacts held in the contact housing are configured to mate with corresponding mating contacts of a mating connector.

20 Claims, 8 Drawing Sheets



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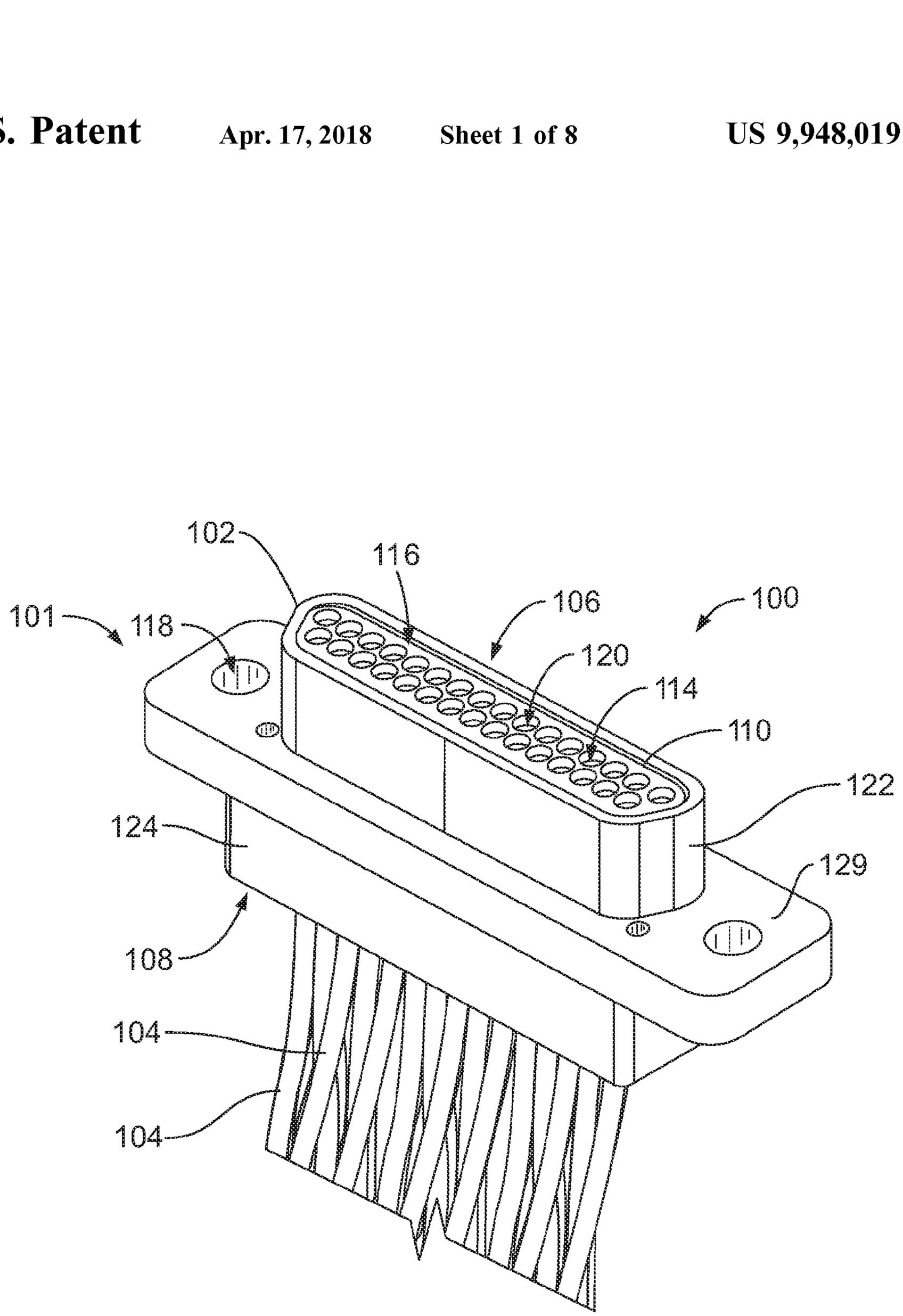


FIG. 1

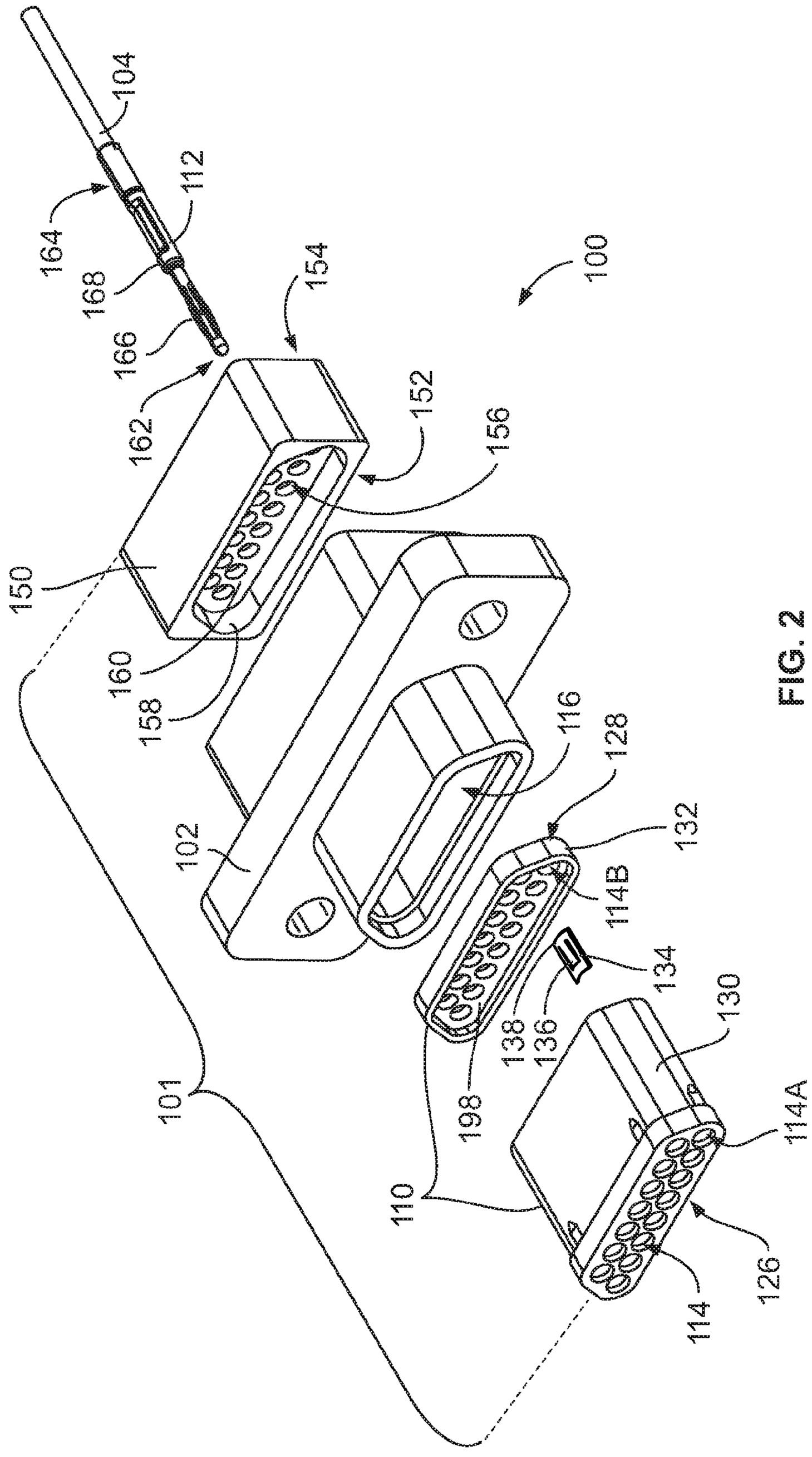
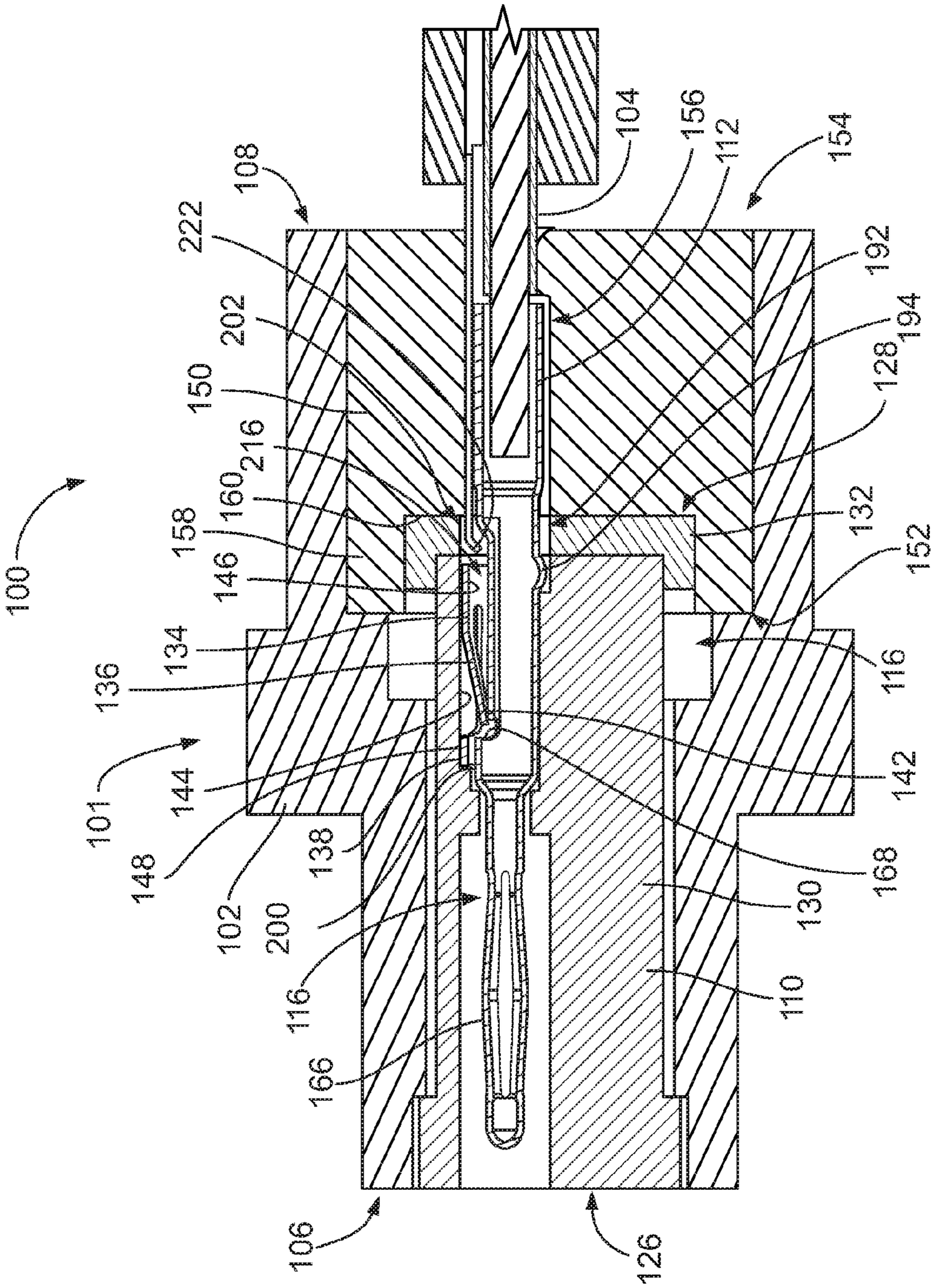

100
101
102
104
110
112
114
114A
114B
116
126
128
130
132
134
136
138
150
152
154
156
158
160
162
164
166
168
198

FIG. 2


100
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118
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128
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132
134
136
138
142
144
146
148
150
152
154
156
158
160
166
168
192
194
200
202
216
222

FIG. 3

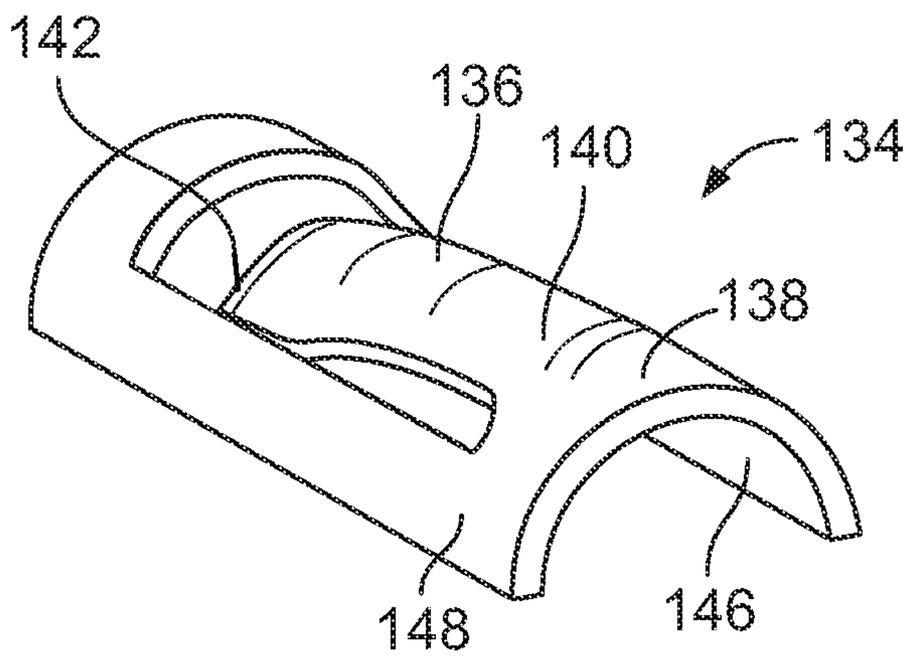
142
136
140
134
138
148
146

FIG. 4

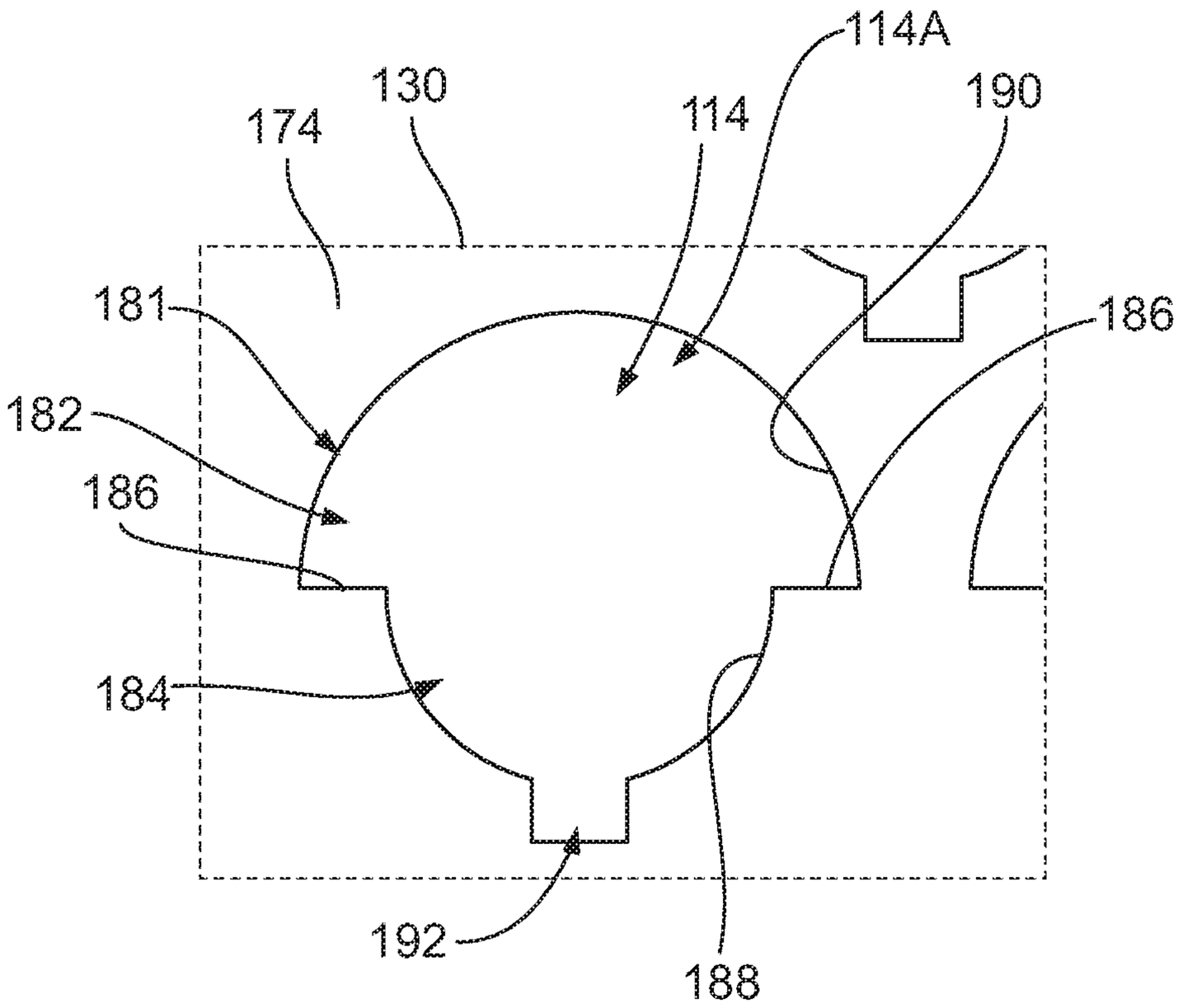
114A
130
174
114
190
181
186
182
186
184
192
188

FIG. 6

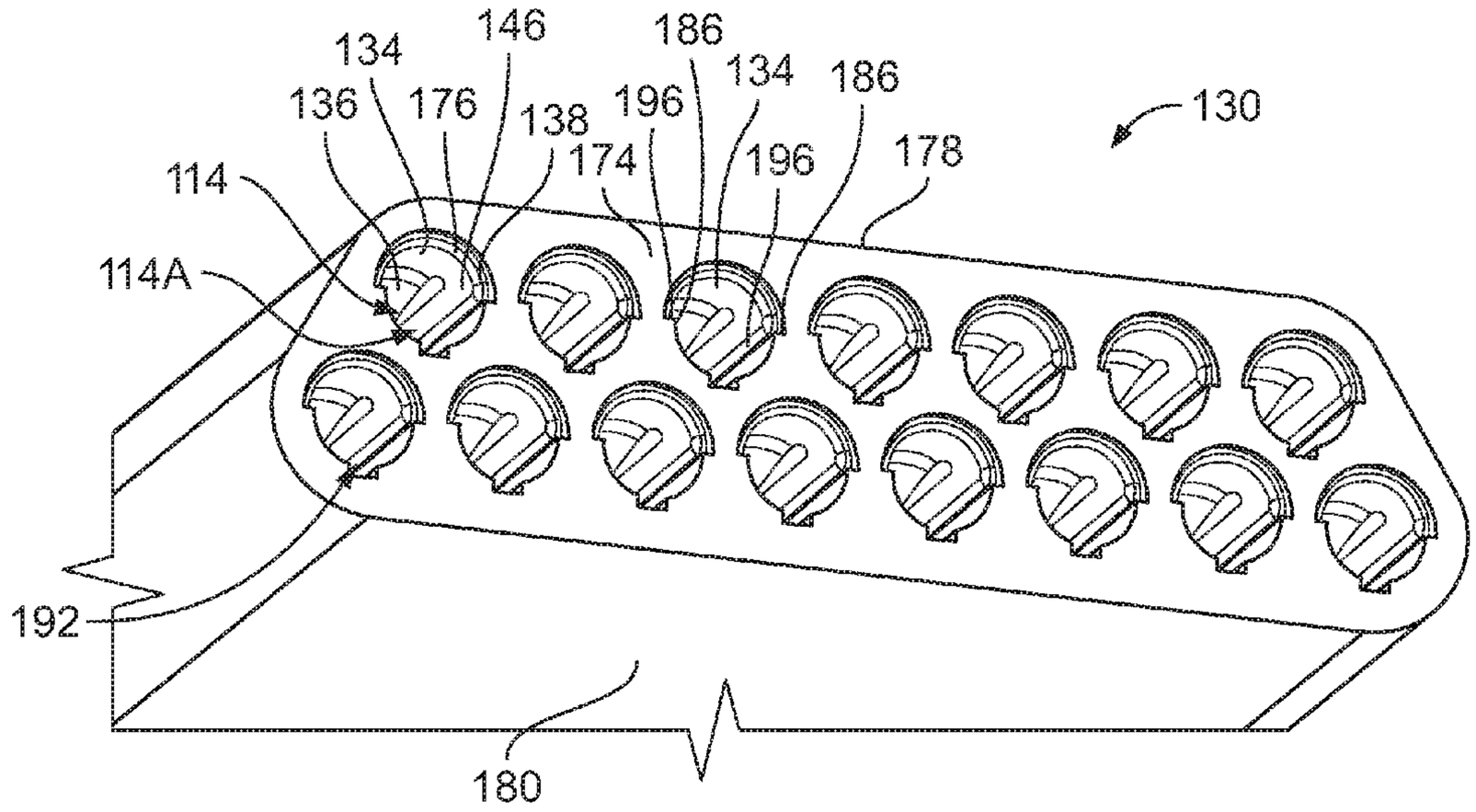
146
134
186
134
186
136
176
138
196
130
174
196
178
114
114A
192
180

FIG. 5

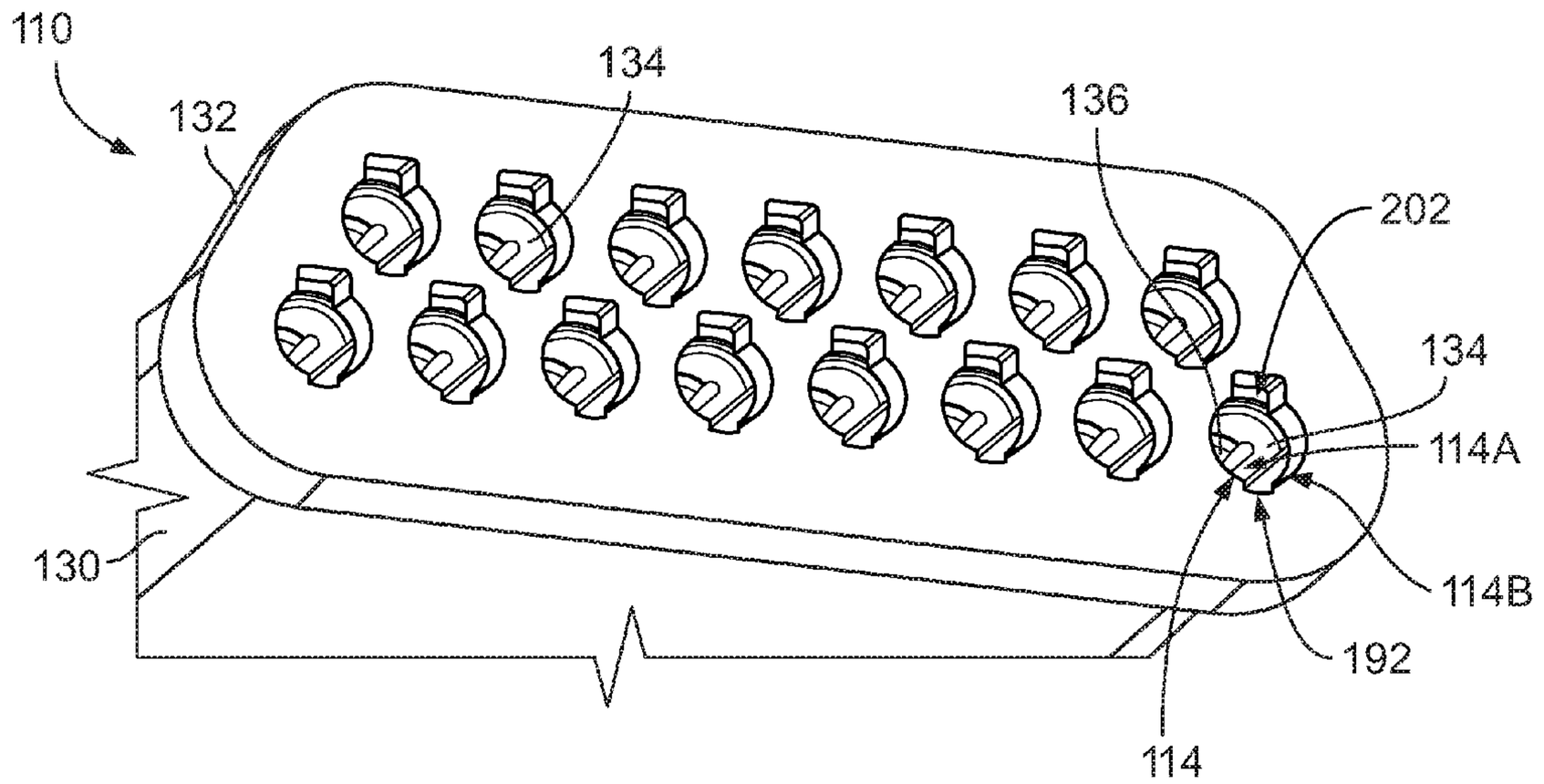
110
134
132
136
202
134
114A
130
114B
192
114

FIG. 7

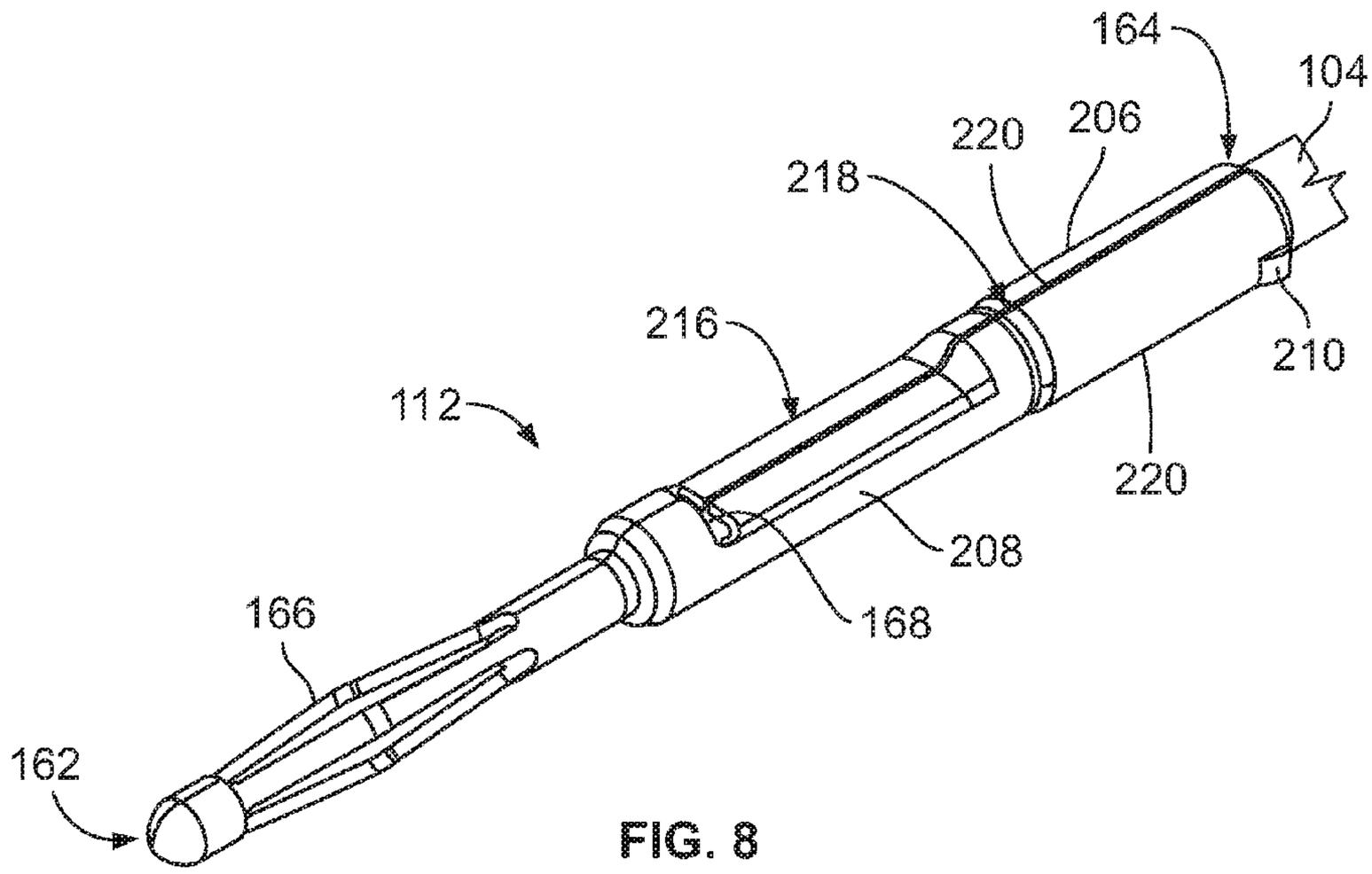
164
104
220
206
218
216
210
112
220
208
166
168
162

FIG. 8

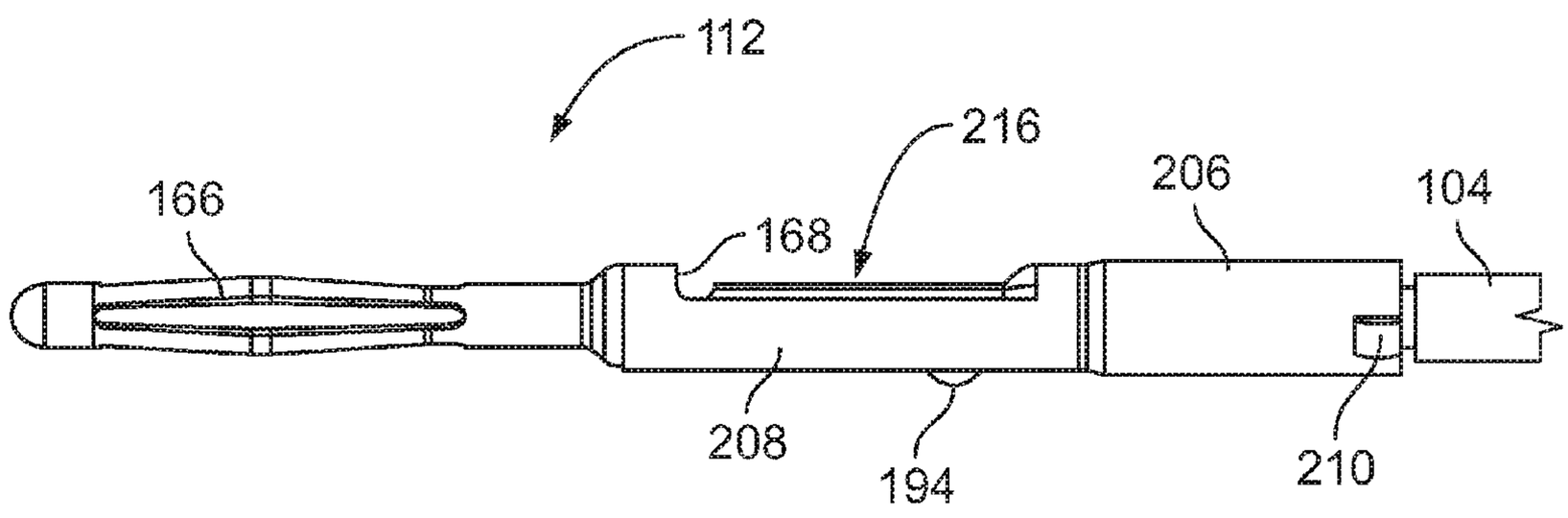
112
216
206
104
166
168
208
194
210

FIG. 9

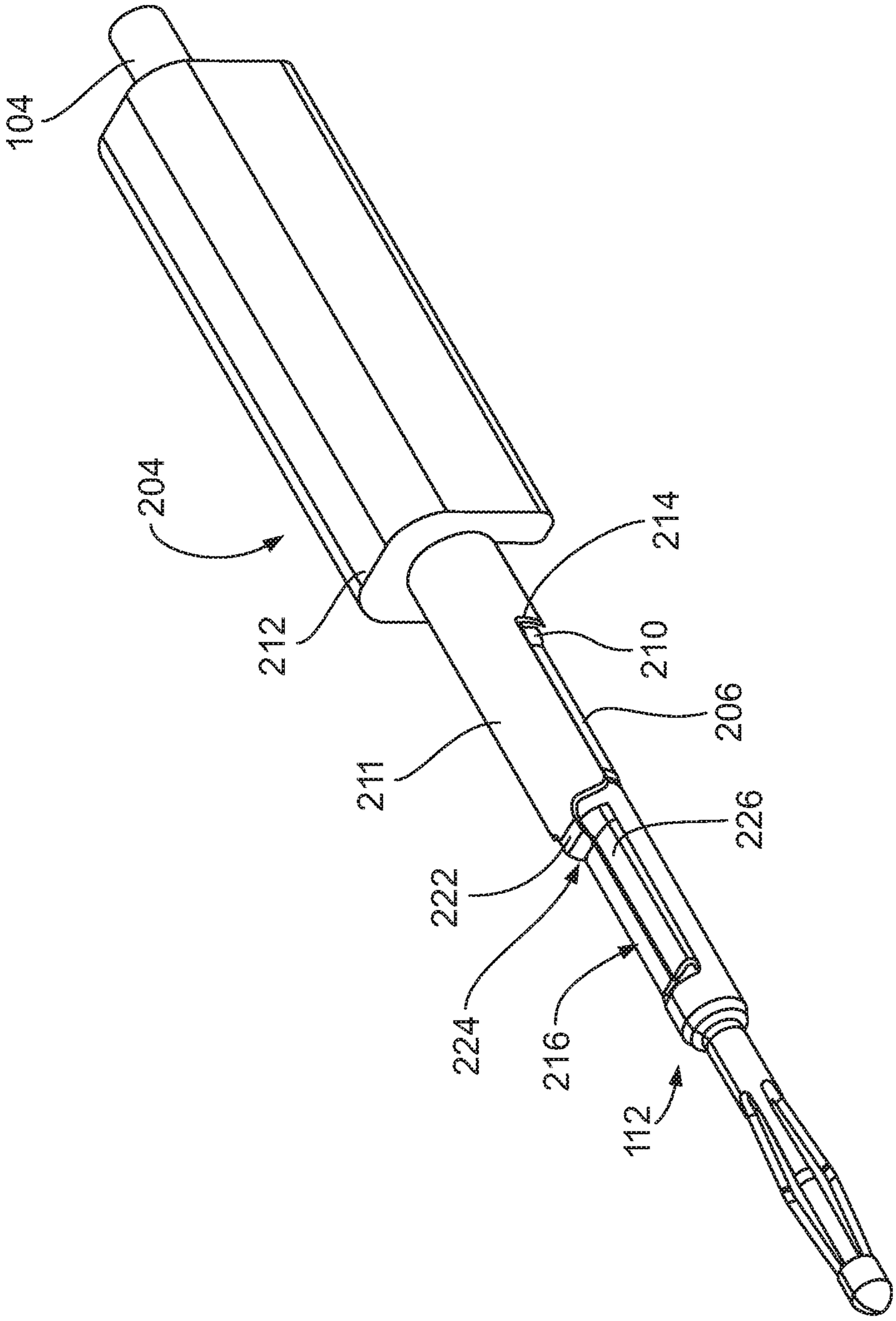

FIG. 10

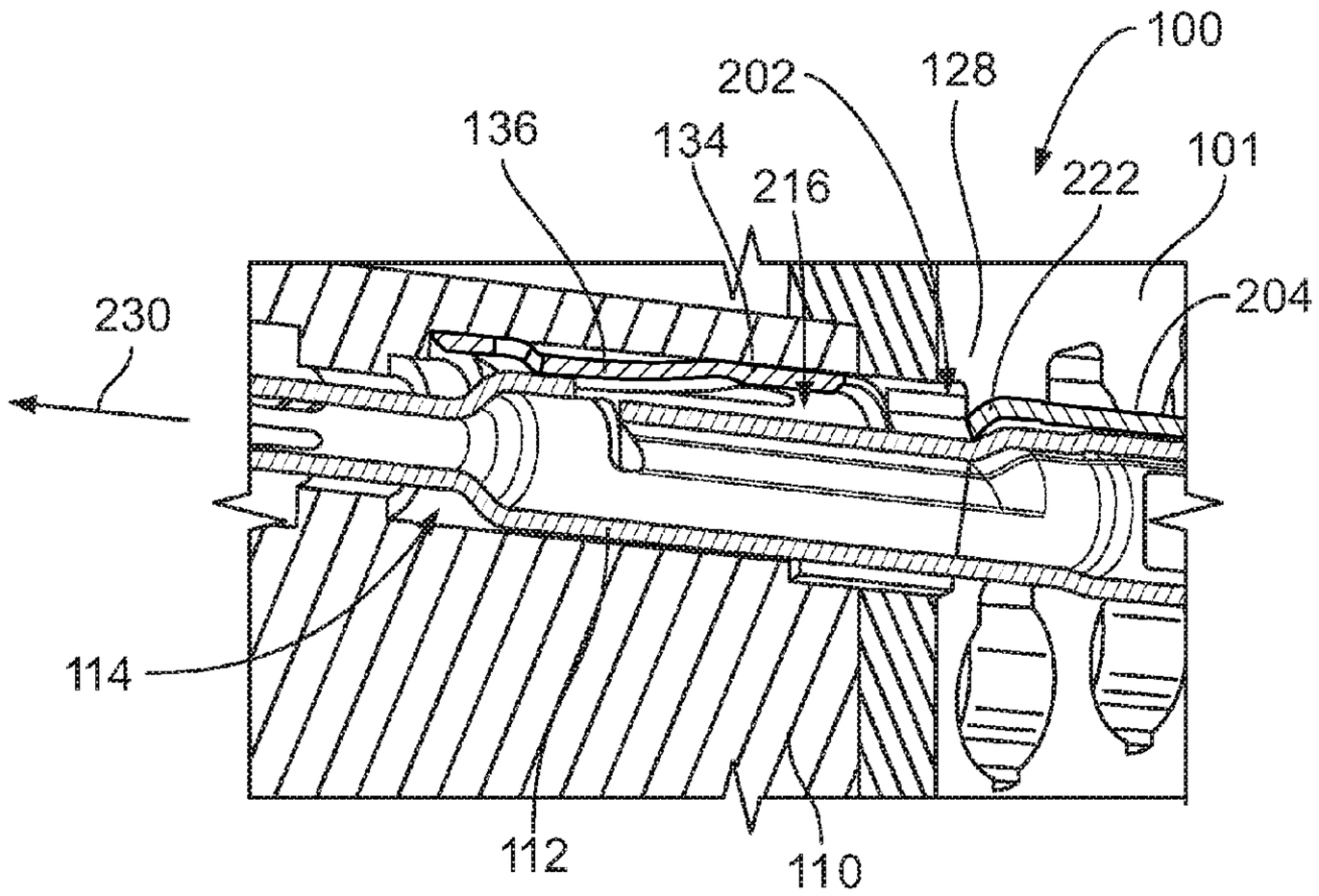
100
202
128
136
134
216
222
101
230
204
114
112
110

FIG. 11

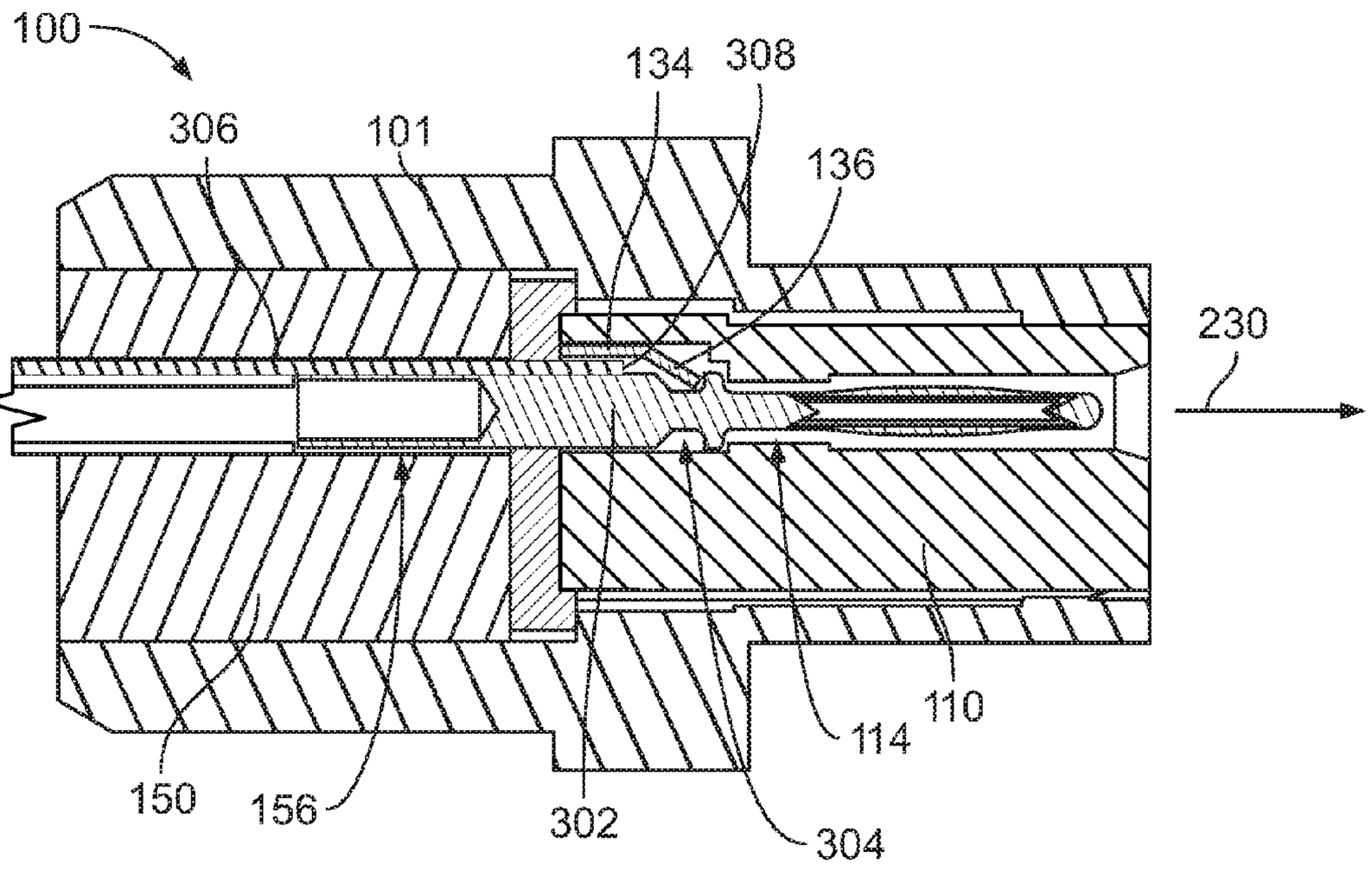
100
134
308
306
101
136
230
150
156
302
304
114
110

FIG. 12

CABLE ASSEMBLY

BACKGROUND OF THE INVENTION

The subject matter herein relates generally to connectors mounted to cables.

Electrical connectors provide communicative interfaces between electrical components where power and/or signals may be transmitted therethrough. For example, the electrical connectors may be used within telecommunication equipment, servers, and data storage or transport devices. Typically, electrical connectors are used in environments, such as in offices or homes, where the connectors are not subjected to constant shock, vibration, and/or extreme temperatures. However, in some applications, such as aerospace or military equipment, the electrical connector must be configured to withstand certain environmental conditions and still effectively transmit power and/or data signals.

In some applications, electrical connectors are terminated to a plurality of electrical cables, which may be referred to as a cable harness. The electrical connectors may be assembled by crimping or soldering each cable to a corresponding electrical contact, seating the contacts in a housing, and then pouring an epoxy into a back cavity of the housing. Upon setting, the epoxy permanently locks the cable-terminated contacts within the housing. Therefore, the individual contacts and cables of the connector are not removable and replaceable. If one of the cables or one of the electrical contacts gets damaged during production or use of the connector, the entire connector may need to be discarded.

Accordingly, there is a need for a cable-mounted electrical connector that offers removable coupling of the electrical contacts to the housing.

BRIEF DESCRIPTION OF THE INVENTION

In one embodiment, a cable-mountable connector is provided including a shell, a contact housing, and multiple finger clips. The shell has a mating end and a cable end opposite the mating end. The shell defines a chamber extending through the shell between the mating and cable ends. The contact housing is held in the chamber of the shell and extends between a front end and a rear end. The contact housing defines contact cavities extending through the contact housing between the front and rear ends. The finger clips are held in the contact cavities of the contact housing. The finger clips have deflectable latches. The contact cavities of the contact housing are configured to removably receive electrical contacts therein through the rear end. The deflectable latch of the finger clip in the corresponding contact cavity is configured to engage a retention shoulder of the electrical contact to removably secure the electrical contact in the contact cavity. The electrical contacts held in the contact housing are configured to mate with a corresponding mating contact of a mating connector.

In another embodiment, a cable assembly is provided including a connector and multiple electrical contacts. The connector includes a shell, a contact housing, multiple finger clips, and multiple electrical contacts. The shell has a mating end and a cable end opposite the mating end. The shell defines a chamber extending through the shell between the mating and cable ends. The contact housing is held in the chamber of the shell and extends between a front end and a rear end. The contact housing defines contact cavities extending through the contact housing between the front and rear ends. The finger clips are held in the contact cavities of the contact housing. The finger clips have deflectable latches. The electrical contacts are removably received in the contact cavities through the rear end of the contact housing. The electrical contacts have mating segments disposed at least proximate to the front end of the contact housing for compliant mating with corresponding mating contacts of a mating connector. The electrical contacts include rear-facing retention shoulders that engage the deflectable latches of the finger clips in the corresponding contact cavities to removably secure the electrical contacts in the contact cavities.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a cable assembly formed in accordance with an exemplary embodiment.

FIG. **2** is an exploded perspective view of the cable assembly according to an embodiment.

FIG. **3** is a side cross-sectional view of the cable assembly in an assembled state.

FIG. **4** is a rear perspective view of a finger clip of the cable assembly.

FIG. **5** is a rear perspective view of a portion of a front housing of a contact housing of the cable assembly according to an embodiment.

FIG. **6** is a close-up view of a rear face of the front housing showing a contact cavity.

FIG. **7** is a rear perspective view of the contact housing with a rear housing secured to the front housing according to an embodiment.

FIG. **8** is a perspective view of one of the electrical contacts of the cable assembly **100** terminated to a cable according to an embodiment.

FIG. **9** is a side view of the electrical contact of FIG. **8**.

FIG. **10** is a perspective view of the electrical contact of FIG. **8** with an insertion tool for loading the contact into a connector of the cable assembly.

FIG. **11** is a cross-sectional view of a portion of the cable assembly showing an electrical contact that is misaligned relative to the connector according to an embodiment.

FIG. **12** is a side cross-sectional view of the cable assembly according to an alternative embodiment.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **1** is a perspective view of a cable assembly **100** formed in accordance with an exemplary embodiment. The cable assembly **100** includes a connector **101** and multiple electrical contacts **112** (shown in FIG. **2**) that are terminated (for example, mechanically and electrically secured) to corresponding cables **104**. The electrical contacts **112** are terminated to the cables **104**, such as via crimping, soldering, welding, or the like. In an exemplary embodiment, the contacts **112** are removably coupled to the connector **101**, such that individual contacts **112** and cables **104** can be removed and replaced and/or repositioned relative to the connector **101** after the cable assembly **100** is initially assembled.

The connector **101** includes a shell **102** that extends between a mating end **106** and a cable end **108** opposite the mating end **106**. The mating end **106** is configured for mating with a mating connector. In the illustrated embodiment, the mating end **106** defines a plug configured to be mated with a receptacle connector; however, the mating end **106** may define a receptacle in alternative embodiments. A plurality of cables **104** extend from the cable end **108** of the shell **102**. The cables **104** may each include one or more

wires or core conductors surrounded by one or more insulation layers. Although not shown in FIG. **1**, at least some of the cables **104** may be commonly surrounded by an insulation layer, such as an outer jacket or a tape layer, outside of the connector **101** to retain the cables **104** in proximity to one another.

The shell **102** defines a chamber **116** extending through the shell **102** between the mating and cable ends **106**, **108**. The connector **101** also includes a contact housing **110** disposed in the chamber **116** of the shell **102**. The contact housing **110** holds a plurality of the electrical contacts **112** (FIG. **2**). For example, each contact **112** is terminated to a different one of the cables **104**. The contact housing **110** defines a plurality of contact cavities **114** that receive corresponding contacts **112**. In the illustrated embodiment, the contact cavities **114** proximate to the mating end **106** of the shell **102** are cylindrical openings having the contacts **112** arranged therein. The contact cavities **114** may receive corresponding mating contacts of a mating connector at the mating end **106** to allow the mating contacts to engage and electrically connect to the contacts **112**. In the illustrated embodiment, the contact cavities **114** are arranged to define a pin mating interface **120** having a designated pattern. The pin mating interface **120** may be designed to meet a particular standard, such as MIL-DTL-83513, or other standards, for intermateability, interchangeability, and performance of a particular connector series. For example, the connector **101** may be a micro-D connector. The pin mating interface **120** in the illustrated embodiment includes 31 contact cavities **114** arranged in two rows, but the contact housing **110** may have a different number and/or arrangement of the contact cavities **114** in an alternative embodiment.

In the illustrated embodiment, the shell **102** includes a flange **129** between the mating end **106** and the cable end **108**. The flange **129** includes mounting openings **118** for securing the shell **102** to the mating connector and/or to a structure (for example, to which the mating connector or the connector **101** is mounted). The shell **102** includes a tongue **122** extending forward from the flange **129** and defining the mating end **106** of the shell **102**. The tongue **122** may be received at least partially within a shroud of the mating connector. The shell **102** further includes a well **124** (for example, a potting well **124**) extending rearward from the flange **129** and defining the cable end **108** of the shell **102**. Although not shown, the well **124** is at least partially open at the cable end **108** to allow to the cables **104** to exit the chamber **116**. The shell **102** in an embodiment is composed of one or more metals, such as aluminum or stainless steel, but may be composed of other materials in other embodiments, such as a carbon fiber or another composite material.

FIG. **2** is an exploded perspective view of the cable assembly **100** according to an embodiment. FIG. **3** is a side cross-sectional view of the cable assembly **100** in an assembled state. The cable assembly **100** in FIG. **3** is sectioned along a median plane that extends the length of the connector **101** between the mating and cable ends **106**, **108** of the shell **102**. The contact housing **110** extends between a front end **126** and an opposite rear end **128**. The front end **126** may be approximately coplanar or flush with the mating end **106** of the shell **102**, as shown in FIG. **3**, when the contact housing **110** is disposed within the chamber **116**. The contact cavities **114** extend fully through the contact housing **110** between the front and rear ends **126**, **128**. The contact housing **110** is composed of an electrically insulative material in an embodiment, such as one or more plastics or other dielectric materials.

Optionally, the contact housing **110** may be a multi-piece structure. For example, as shown in FIG. **2**, the contact housing **110** may include a front housing **130** and a rear housing **132** that each form part of the contact housing **110**. The front housing **130** defines the front end **126** of the contact housing **110**, and the rear housing **132** defines the rear end **128**. The front and rear housings **130**, **132** each define respective front and rear portions of the contact cavities **114**. For example, the front portions **114**A of the contact cavities **114** defined in the front housing **130** at least partially align with and are fluidly connected to the rear portions **114**B of the contact cavities **114** defined in the rear housing **132** when the front and rear housings **130**, **132** are loaded in the shell **102**. The front housing **130** optionally may be secured to the rear housing **132** at an interface using an adhesive, an epoxy, a mechanical fastener, or the like. The front and rear housings **130**, **132** may be composed of the same or different materials.

The connector **101** includes finger clips **134** held in the contact cavities **114** of the contact housing **110**. For example, although only one finger clip **134** is shown in FIGS. **2** and **3**, each contact cavity **114** may include a corresponding finger clip. The illustrated finger clips **134** may be representative of the other finger clips. Additional reference is made to FIG. **4**, which is a rear perspective view of the finger clip **134**. The finger clips **134** each have a deflectable latch **136** extending from a body **138** of the finger clip **134**. The deflectable latch **136** in an embodiment is cantilevered from the body **138**. The latch **136** extends from a fixed end **140** attached to the body **138** to a free end **142** that is not attached to the body **138**. In an embodiment, as shown in FIG. **3**, the finger clip **134** is oriented in the contact cavity **114** such that the free end **142** is located frontward of the fixed end **140**, meaning that the free end **142** is more proximate to the front end **126** of the contact housing **110** than a proximity of the fixed end **140** to the front end **126**. The finger clip **134** is held in the contact cavity **114** such that the body **138** engages or is at least proximate to a peripheral wall **144** of the contact housing **110** defining the contact cavity **114**. The deflectable latch **136**, in a natural resting position or un-biased position, extends from the body **138** radially inward towards a radial center of the contact cavity **114**. The latch **136** is configured to be deflected radially outwards towards the peripheral wall **144** by the electrical contact **112** as the electrical contact **112** is inserted into the contact cavity **114**. The finger clip **134** in an embodiment is composed of one or more metals, and may be stamped and formed from a sheet.

As shown in FIG. **4**, the body **138** of the finger clip **134** is curved. The body **138** includes an inner side **146** and an opposite outer side **148**. Within the contact cavity **114** of the contact housing **110**, the outer side **148** engages or at least faces the peripheral wall **144** of the contact cavity **114**, and the inner side **146** faces the electrical contact **112** received in the contact cavity **114**. The finger clip **134** is curved to accommodate the electrical contact **112** moving beyond the finger clip **134** in the contact cavity **114**. In an embodiment, the finger clip **134** may extend along approximately half of a perimeter of the contact cavity **114**, although due to the body **138** being curved, the finger clip **134** occupies less than half of a cross-sectional area of the contact cavity **114** (to provide space for the contact **112**). The finger clip **134** may have a semi-circular cross-sectional shape. In other embodiments, the finger clip **134** may extend along more or less than half of the perimeter of the contact cavity **114**.

Referring back to FIGS. **2** and **3**, the connector **101** further includes a grommet **150** that is held in the chamber **116** of

the shell **102** rearward of the contact housing **110**. The grommet **150** extends between a front end **152** and a rear end **154**, and the front end **152** faces and/or receives the rear end **128** of the contact housing **110**. The rear end **154** may be approximately coplanar or flush with the cable end **108** of the shell **102** when the grommet **150** is disposed in the chamber **116**. The grommet **150** defines multiple apertures **156** that extend through the grommet **150** between the front and rear ends **152**, **154**. When assembled within the shell **102**, the apertures **156** align with the contact cavities **114** of the contact housing **110**. Therefore, the contact cavities **114** and the apertures **156** define respective segments of openings that extend continuously through the chamber **116** of the shell **102** between the mating end **106** and the cable end **108**. The grommet **150** may engage the rear end **128** of the contact housing **110** at an interface, and may seal the interface to prevent debris and other contaminants from migrating into the contact cavities **114** of the contact housing **110**. For example, the grommet **150** may include a rim **158** that extends from a front face **160** of the grommet **150** to the front end **152**. The apertures **156** are located along the front face **160**. The rim **158** extends around a perimeter of the front face **160**. When loaded into the shell **102**, the rear end **128** of the contact housing **110** is received within the rim **158** and may engage the front face **160**, as shown in FIG. **3**. The grommet **150** may be composed of a dielectric material, such as plastic, rubber, or the like. The grommet **150** may be at least partially compressible to allow the material of the grommet **150** to seal the apertures **156** around the electrical contacts **112** and/or cables **104** therein.

Once assembled, the connector **101** is configured to receive one or more of the electrical contacts **112** to form the cable assembly **100**. Only one electrical contact **112** is shown in FIGS. **2** and **3**, but other electrical contacts **112** are received into the connector **101** may be similar or identical to the illustrated electrical contact **112**. The electrical contact **112** is elongated between a front **162** and a rear **164**. The contact **112** has a mating segment **166** that defines the front **162**. The cable **104** is terminated to the contact **112** and extends from the rear **164**. The electrical contact **112** is terminated to the cable **104** via crimping, soldering, welding, or the like, outside of the connector **101**. The electrical contact **112** is subsequently loaded through one of the apertures **156** of the grommet **150** into a corresponding contact cavity **114** of the contact housing **110**. The electrical contact **112** is loaded, front **162** first, in a frontward direction from the rear ends **154**, **128** of the grommet **150** and the contact housing **110**, respectively, towards the front ends **152**, **126**. As shown in FIG. **3**, when the contact **112** reaches a fully inserted position in the contact cavity **114**, the deflectable latch **136** of the finger clip **134** engages a retention shoulder **168** of the electrical contact **112** to secure the electrical contact **112** in the contact cavity **114**. The contact **112** is secured in the contact cavity **114** because the finger clip **134** blocks the contact **112** from backing out of the cavity **114** towards the cable end **108** of the shell **102**. For example, the free end **142** of the latch **136** abuts against the retention shoulder **168** to mechanically block rearward movement of the contact **112**.

The electrical contact **112** in the contact housing **110** is configured to mate with a corresponding mating contact of a mating connector. For example, as shown in FIG. **3**, the mating segment **166** of the contact **112** is located within the contact cavity **114** at least proximate to the front end **126** to engage a mating contact. In the illustrated embodiment, the mating segment **166** is a compliant pin that is configured for compliant mating to a socket contact of the mating connector. In other various embodiments, the mating segment **166** may be a female pin having a socket configured to receive a male pin of the mating connector.

In an exemplary embodiment, the electrical contacts **112** are removably received and secured in the contact cavities **114**, such that the electrical contacts **112** may be selectively removed from the contact cavities **114** without damaging the connector **101** or the contacts **112**. The electrical contact **112** shown in FIG. **3** may be removed by forcing the deflectable latch **136** radially outward towards the peripheral wall **144** of the contact cavity **114** that engages or is at least proximate to the body **138** of the finger clip **134**. In the illustrated embodiment, the latch **136** is deflected vertically upwards relative to the connector **101**. Upon the free end **142** of the latch **136** moving to a clearance position that is radially outward of (for example, above) the retention shoulder **168** of the electrical contact **112**, the latch **136** allows the contact **112** to back out of the contact cavity **114**. For example, the contact **112** is able to be pulled rearward when the latch **136** is in the clearance position such that the retention shoulder **168** moves past the latch **136** without stubbing or catching on the free end **142**. In an embodiment, the latch **136** is forced to the clearance position by a blade **306** (shown in FIG. **12**) of a removal tool that enters the contact cavity **114** through the rear end **128**. The blade **306** deflects the latch **136** radially outward as the blade **306** is moved longitudinally through the contact cavity **114** towards the front end **126**. In an embodiment, the blade **306** extends through the corresponding aperture **156** of the grommet **150** before entering the contact cavity **114**.

Since the cable assembly **100** has removable electrical contacts **112** relative to the connector **101**, the cable assembly **100** may provide various technical advantages over known cable assemblies in which cable-mounted contacts are potted via an epoxy or the like into the connector housings and are not removable. For example, the cable assembly **100** is able to be serviced in the field without replacing the cable assembly **100** entirely. If one or more of the contacts **112** and/or cables **104** are damaged in the field, the damaged cable-mounted contacts **112** can be removed from the cable assembly **100** and replaced with new cable-mounted contacts **112**. Furthermore, the removability allows for customization of the cable assembly **100**, as an operator can select the number and the arrangement of cable-mounted contacts **112** secured in the connector **101**.

FIG. **5** is a rear perspective view of a portion of the front housing **130** of the contact housing **110** according to an embodiment. FIG. **6** is a close-up view of a rear face **174** of the front housing **130** showing one of the contact cavities **114**. FIG. **7** is a rear perspective view of the contact housing **110** with the rear housing **132** secured to the front housing **130** according to an embodiment. As shown in FIG. **5**, the finger clips **134** are disposed within the front portions **114**A of the contact cavities **114** defined by the front housing **130**. The finger clips **134** have back ends **176** that are located flush with, or at proximate to, the rear face **174** of the front housing **130**. Each contact cavity **114** receives one finger clip **134**. In an exemplary embodiment, all of the finger clips **134** have a common orientation relative to the front housing **130** of the contact housing **110** (shown in FIG. **7**). For example, the front housing **130** has a top side **178** and a bottom side **180**. As used herein, relative or spatial terms such as "front," "rear," "top," "bottom," "first," and "second," are only used to distinguish the referenced elements and do not necessarily require particular positions or orientations relative to the surrounding environment of the cable assembly **100** (shown in FIG. **1**). The finger clips **134** are

angularly oriented relative to the front housing **130** such that the deflectable latches **136** are disposed along the top portions of the corresponding cavities **114**. The common orientation of the finger clips **134** allows (and requires) the electrical contacts **112** (shown in FIG. **1**) received in the cavities **114** to have common orientations for the latches **136** to properly engage and secure the contacts **112**.

Referring now to FIG. **6**, the contact cavities **114** (along the front portions **114**A) may have a cross-sectional profile **181** that includes a clip region **182** and a reduced diameter region **184**. The clip region **182** is disposed above the reduced diameter region **184** in the illustrated embodiment. The contact cavity **114** has a generally curved profile along both the clip region **182** and the reduced diameter region **184**, although the clip region **182** has a greater radius and/or diameter than the reduced diameter region **184**. The reduced diameter region **184** is sized sufficiently large to be able to accommodate an electrical contact **112**. The front housing **130** includes ledges **186** at the interfaces between the clip region **182** and the reduced diameter region **184**. The ledges **186** extend radially outward from a peripheral wall **188** of the reduced diameter region **184** to a peripheral wall **190** of the clip region **182**. The two ledges **186** shown in FIG. **6** are disposed approximately midway along a height of the contact cavity **114** (between the top and bottom sides **178**, **180** of the front housing **130**) and extend generally parallel to each other.

The profile **181** of the contact cavity **114** optionally also includes a notch **192** extending radially outward from a perimeter of the cavity **114** along the reduced diameter region **184**. The notch **192** is configured to receive a protrusion **194** (shown in FIG. **9**) of one of the electrical contacts **112** therein as the electrical contact **112** is inserted into the contact cavity **114** to ensure that the electrical contact **112** is angularly aligned with the orientation of the finger clip **134** in the contact cavity **114**. For example, if an operator inserting one of the cable-mounted contacts **112** into the connector **101** (shown in FIG. **3**) experiences a stubbing force due to the protrusion **194** abutting against the rear end **128** of the contact housing **110**, then the feedback indicates that the protrusion **194** is not angularly aligned with the notch **192**, and the contact **112** is therefore not angularly aligned with the finger clip **134**. As shown in FIGS. **5** and **7**, the notches **192** may be defined in the rear portions **114**B of the cavities **114** of the rear housing **132**, and may also extend at least partially through the front portions **114**A defined by the front housing **130**. FIG. **3** shows the protrusion **194** of the contact **112** received in the notch **192** along the front housing **130**. In an alternative embodiment, the notches **192** are only defined in the rear portions **114**B of the cavities **114** defined by the rear housing **132**, such that the protrusions **194** are within the rear housing **132** when the contacts **112** are fully inserted into the cavities **114**.

Referring now to FIGS. **5** and **6**, the finger clips **134** are disposed in the clip regions **182** of the front portions **114**A of the contact cavities **114**. The finger clips **134** are retained in the clip regions **182** by the ledges **186**. For example, side edges **196** of the clips **134** may sit on the ledges **186**. The finger clips **134** are curved to extend generally along the perimeters of the clip regions **182**. The curved inner side **146** of the body **138** of each finger clip **134** has a radius that may be approximately equal to the radius of the reduced diameter region **184** of the corresponding contact cavity **114**. Therefore, the finger clip **134** and the reduced diameter region **184** together define a perimeter of the contact cavity **114** (along the length of the finger clip **134**). The inner side **146** of the finger clip **134** constructively defines a peripheral wall of the contact cavity **114**. As an electrical contact **112** is received into the contact cavity **114**, the finger clip **134** surrounds a circumferential portion of the contact **112**, and the reduced diameter region **184** surrounds a remaining circumferential portion of the contact **112**.

Referring now to FIGS. **5** and **7**, the contact housing **110** is assembled by securing the rear housing **132** to the front housing **130** with the finger clips **134** already disposed within the front portions **114**A of the contact cavities **114** defined by the front housing **130**. In an embodiment, the rear housing **132** is configured to lock the finger clips **134** within the contact cavities **114** when the rear housing **132** is secured to the front housing **130**. For example, the rear portions **114**B of the contact cavities **114** have a smaller cross-sectional size, a different cross-sectional shape, and/or are slightly offset from the front portions **114**A defined by the front housing **130**, so a front face **198** (shown in FIG. **2**) of the rear housing **132** blocks the finger clips **134** from moving rearward out of the front portions **114**A of the cavities **114**. In an embodiment, the rear portions **114**B have a radius and/or diameter that is approximately equal to the reduced diameter region **184** of the front portions **114**B. The finger clips **134** in the clip regions **182** have larger outer diameters than the diameters of the rear portions **114**B, so the back ends **176** of the finger clips **134** abut against the rear housing **132** proximate to the edges of the rear portions **114**B. However, the cable-mounted electrical contacts **112** are able to fit within the rear portions **114**B to be received in the contact cavities **114**. As shown in FIG. **3**, the finger clips **134** may each be configured to abut against a rear-facing shoulder **200** in the contact cavity **114** to block axial movement of the finger clip **134** towards the front end **126** of the contact housing **110**.

In an embodiment, the rear portions **114**B of the contact cavities **114** defined by the rear housing **132** each include a clearance indent **202** extending radially outward from a perimeter of the contact cavity **114**. The clearance indent **202** in the illustrated embodiment is located along a top of the corresponding contact cavity **114**, but may have other angular locations along the perimeter of the contact cavity **114** in other embodiments. The clearance indent **202** aligns angularly with the deflectable latch **136** of the finger clip **134** disposed within the corresponding contact cavity **114**. The clearance indent **202** provides a path for a removal tool and/or an insertion tool to enter the contact cavity **114** to manipulate the corresponding electrical contact **112** relative to the contact cavity **114**. The clearance indent **202** is used for ensuring that the removal and/or insertion tool is properly aligned relative to the finger clip **134**. In the illustrated embodiment the clearance indent **202** is located along the rear portion **114**B of each contact cavity **114**, and is not located along the front portion **114**A defined by the front housing **130**.

FIG. **8** is a perspective view of one of the electrical contacts **112** of the cable assembly **100** (shown in FIG. **1**) terminated to a cable **104** according to an embodiment. FIG. **9** is a side view of the electrical contact **112** of FIG. **8**. FIG. **10** is a perspective view of the electrical contact **112** of FIG. **8** with an insertion tool **204** for loading the contact **112** into the connector **101** (shown in FIG. **3**). The electrical contact **112** includes the mating segment **166** at the front **162** and a termination barrel **206** rearward of the mating segment **166** at the rear **164**. The termination barrel **206** surrounds and mechanically and electrically connects to an end of the cable **104**. For example, the termination barrel **206** may be crimped, soldered, welded, or otherwise mechanically

secured to the cable **104**. The termination barrel **206** is generally cylindrical. The termination barrel **206** includes at least one push tab **210** that extends radially outward from a cylindrical outer perimeter of the barrel **206**. The push tab **210** may be formed by a shearing process, a stamping process, a molding process, or the like. Alternatively, the push tab **210** may be formed inherently during a crimping process that terminates the contact **112** to the cable **104**, as the compressive forces applied to the barrel **206** may cause the barrel **206** at the rear **164** to bulge outward relative to a compressed area of the barrel **206**. As shown in FIG. **10**, the push tab **210** is engaged by the insertion tool **204** shown in FIG. **10** to allow the tool **204** to push the cable-mounted electrical contact **112** into the contact cavity **114** (FIG. **3**) of the connector **101** (FIG. **3**). For example, the insertion tool **204** includes an arm **211** extending from a handle **212**. The tool **204** further includes a ridge **214** protruding from the arm **211**. The arm **211** and the handle **212** are curved to at least partially cradle the electrical contact **112**, and the ridge **214** abuts against the push tab **210**.

The electrical contact **112** defines a depressed region **216** rearward of the mating segment **166**. The diameter of the generally-cylindrical contact **112** is reduced along the depressed region **216** relative to areas of the contact **112** in front of and rearward of the depressed region **216**. The rear-facing retention shoulder **168** of the electrical contact **112** that is configured to engage the deflectable latch **136** (FIG. **3**) of the finger clip **134** (FIG. **3**) defines a front end of the depressed region **216**. In an embodiment, the depressed region **216** is disposed along an intermediate segment **208** of the contact **112** that is axially between the mating segment **166** and the termination barrel **206**. In another embodiment, the depressed region **216** may be located along the termination barrel **206**. As shown in FIG. **3**, when the electrical contact **112** is in the fully inserted position in the contact cavity **114**, the latch **136** is received in the depressed region **216**. For example, the portion of the contact **112** in front of the depressed region **216** is configured to force the latch **136** to deflect radially outward. Once the rear-facing retention shoulder **168** moves beyond the free end **142** of the latch **136**, the latch **136** resiliently returns towards an unbiased position by moving radially inward into the depressed region **216** of the contact **112**. Rearward movement of the electrical contact **112** causes the rear-facing retention shoulder **168** to engage and abut against the free end **142** of the latch **136**, securing the contact **112** in the cavity **114** by blocking additional rearward movement of the contact **112**.

In an exemplary embodiment, the electrical contact **112** is stamped and formed into the generally cylindrical shape from a sheet of metal. For example, the electrical contact **112** includes a seam **218** that extends the length of the contact **112** between the front **162** and the rear **164**. The seam **218** is defined between rolled edges **220** of the sheet that are rolled towards each other to define the generally cylindrical shape of the contact **112**. The rear-facing retention shoulder **168** optionally may be formed by shearing or cutting the contact **112** to define a sheared edge.

In the illustrated embodiment, the depressed region **216** does not extend along a full perimeter of the contact **112**, but is located along a top portion of the contact **112**. Since the depressed region **216** does not extend around a full perimeter of the contact **112**, the contact **112** must be angularly aligned with the finger clip **134** when the contact **112** is inserted into the corresponding contact cavity **114** in order for the latch **136** to align with and engage the retention shoulder **168**. As shown in FIG. **10**, the insertion tool **204** includes a finger **222** at a distal end **224** of the arm **211**. The finger **222** is curved relative to the arm **211**. When the insertion tool **204** engages an electrical contact **112**, the arm **211** cradles the termination barrel **206** and the finger **222** extends into the depressed region **216**. The finger **222** may abut against a base surface **226** of the contact **112** along the depressed region **216** in order to rotationally fix the contact **112** to the insertion tool **204** so the contact **112** cannot rotate relative to the tool **204**. The insertion tool **204** optionally may be rotationally fixed to the contact **112**, instead of or in addition to the finger **222**, via engagement of the one or more push tabs **210** of the contact **112** with corresponding edges of the arm **211** of the tool **204**.

As shown in FIG. **9**, the protrusion **194** of the contact **112** is spaced apart angularly from the depressed region **216**. For example, the protrusion **194** shown in FIG. **9** is located along a bottom portion of the contact **112**, approximately 180 degrees from the depressed region **216** at the top portion. The protrusion **194** may be formed by stamping, shearing, or molding a metal material of the contact **112**. As described above, the protrusion **194** is used for ensuring that the contact **112** aligns with the finger clip **134** as the contact **112** is loaded into the corresponding contact cavity **114**. For example, the protrusion **194** is received within the notch **192** (shown in FIG. **3**) of the contact housing **110** when the contact **112** is properly aligned with the contact housing **110** and the finger clip **134** held therein.

FIG. **11** is a cross-sectional view of a portion of the cable assembly **100** showing an electrical contact **112** that is misaligned relative to the connector **101** according to an embodiment. Since the contact **112** is angularly misaligned relative to the deflectable latch **136** of the finger clip **134**, the latch **136** cannot be received properly in the depressed region **216** to reliably secure the contact **112** in the cavity **114**. The cable assembly **100** is configured to provide stubbing feedback to an operator operating the insertion tool **204** when the contact **112** is misaligned. For example, before the contact **112** reaches the fully inserted position in the cavity **114**, the finger **222** of the insertion tool **204** abuts against the rear end **128** of the contact housing **110**, which blocks further movement of the contact **112** and the tool **204** in a forward loading direction **230**. If, on the other hand, the contact **112** is aligned with the finger clip **134**, the finger **222** of the insertion tool **204** is configured to be received in the clearance indent **202** instead of abutting against the rear end **128**. FIG. **3** shows the finger **222** disposed in the clearance indent **202**. Optionally, the protrusion **194** (shown in FIG. **9**) of the contact **112** may be configured to abut against the rear end **128** of the contact housing **110** instead of, or in addition to, the finger **222** of the insertion tool **204** when the contact **112** is misaligned to prevent the contact **112** from reaching the fully inserted position. When the contact **112** is aligned properly, as shown in FIG. **3**, the protrusion **194** is received in the notch **192** to allow the contact **112** to be fully loaded into the cavity **114**.

FIG. **12** is a side cross-sectional view of the cable assembly **100** according to an alternative embodiment. The cable assembly **100** includes a cable-mounted electrical contact **302** that is formed via machining instead of stamping and forming. The contact **302** includes a depressed region **304** that extends fully around a circumference of the contact **302**, so angular alignment between the contact **302** and the deflectable latch **136** of the finger clip **134** in the cavity **114** is not a concern. For example, the latch **136** can enter the depressed region **304** regardless of the relative angular orientation between the contact **302** and the finger clip **134**.

The contact **302** is removably secured to the connector **101** in the illustrated embodiment. In an embodiment, the contact **302** is configured to be removed by a removal tool (not shown) that includes an elongated blade **306**. The tool is manipulated to insert the blade **306** into the aperture **156** of the grommet **150** and the contact cavity **114** of the contact housing **110**. The blade **306** is disposed between the contact **302** and the deflectable latch **136** in the cavity **114**. Movement of the removal tool in the forward loading direction **230** causes a distal tip **308** of the blade **306** to engage and deflect the latch **136** radially outward until the latch **136** reaches a clearance position. The contact **302** is able to be pulled rearward out of the cavity **114** when the latch **136** is in the clearance position.

It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its scope. Dimensions, types of materials, orientations of the various components, and the number and positions of the various components described herein are intended to define parameters of certain embodiments, and are by no means limiting and are merely exemplary embodiments. Many other embodiments and modifications within the spirit and scope of the claims will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. § 112(f), unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

What is claimed is:

1. A cable-mountable connector comprising:

a shell having a mating end and a cable end opposite the mating end, the shell defining a chamber extending through the shell between the mating and cable ends;

a contact housing held in the chamber of the shell and extending between a front end and a rear end, the contact housing defining contact cavities extending through the contact housing between the front and rear ends; and

multiple finger clips held in the contact cavities of the contact housing, the finger clips having curved bodies and deflectable latches extending from the curved bodies, each curved body extending along less than an entirety of a perimeter of the corresponding contact cavity, all of the finger clips in the contact cavities having a common angular orientation relative to the contact housing,

wherein the contact cavities of the contact housing are configured to removably receive electrical contacts therein through the rear end, the deflectable latch of the finger clip in the corresponding contact cavity configured to engage a retention shoulder of the electrical contact to removably secure the electrical contact in the contact cavity, the electrical contacts held in the contact housing configured to mate with corresponding mating contacts of a mating connector.

2. The connector of claim **1**, wherein the deflectable latches of the finger clips in the contact cavities are configured to be deflected radially outward towards a peripheral wall of the corresponding contact cavity by a blade of a removal tool that enters the contact cavity through the rear end, the latch disengaging the retention shoulder of the electrical contact upon deflecting outward to allow removal of the electrical contact from the contact cavity.

3. The connector of claim **1**, wherein the contact cavities at the rear end of the contact housing include a clearance indent extending radially outward from the perimeter of the contact cavity, the clearance indent angularly aligning with the deflectable latch of the finger clip, the clearance indent providing a path for at least one of a removal tool or an insertion tool to enter the contact cavity to move the corresponding electrical contact relative to the contact cavity.

4. The connector of claim **1**, further comprising a grommet held in the chamber of the shell, the grommet extending between a front end and a rear end, the front end facing the rear end of the contact housing, the grommet defining apertures through the grommet between the front and rear ends that align with the contact cavities of the contact housing, the grommet composed of a dielectric material.

5. The connector of claim **1**, wherein the contact cavities have a cross-sectional profile that includes clip region and a reduced diameter region, the contact housing including a ledge at each of two interfaces between the clip region and the reduced diameter region, the finger clip disposed in the clip region and configured to engage the ledges to retain an orientation of the finger clip relative to the contact housing.

6. The connector of claim **5**, wherein the contact cavities at the rear end of the contact housing include a notch extending radially outward from the perimeter of the contact cavity along the reduced diameter region, the notch configured to receive a protrusion of one of the electrical contacts therein as the electrical contact is inserted into the contact cavity to ensure that the electrical contact is angularly aligned with the finger clip in the contact cavity.

7. The connector of claim **5**, wherein the curved body of each finger clip includes an outer side and an inner side, the outer side facing a peripheral wall of the contact cavity along the clip region, the inner side of the curved body having a radius approximately equal to a radius of the reduced diameter region of the contact cavity.

8. The connector of claim **1**, wherein the deflectable latches of the finger clips are cantilevered and extend from a fixed end attached to a body of the respective finger clip to a free end that is not attached to the body, the free end disposed more proximate to the front end of the contact housing than a proximity of the fixed end to the front end.

9. The connector of claim **1**, wherein the contact housing is defined by a front housing and a rear housing that are secured together, the front housing defining the front end of the contact housing and the rear housing defining the rear end, the front and rear housings defining respective front and rear portions of the contact cavities, the finger clips held in the front portions of the contact cavities, the rear portions of the contact cavities having at least one of a smaller cross-sectional size or a different cross-sectional shape than the front portions such that the rear housing blocks the finger clips from moving rearward out of the front portions of the contact cavities.

10. The connector of claim 1, wherein the curved bodies of the finger clips are generally semi-circular and extend along approximately half of the perimeter of the corresponding contact cavity.

11. A cable assembly comprising:

a connector including a shell, a contact housing, and multiple finger clips, the shell having a mating end and a cable end opposite the mating end, the shell defining a chamber extending through the shell between the mating and cable ends, the contact housing held in the chamber of the shell and extending between a front end and a rear end, the contact housing defining contact cavities extending through the contact housing between the front and rear ends, the finger clips held in the contact cavities of the contact housing, the finger clips having deflectable latches, the contact cavities each defining a notch extending outward from a perimeter of the contact cavity; and

multiple electrical contacts removably received in the contact cavities through the rear end of the contact housing, the electrical contacts having mating segments disposed at least proximate to the front end of the contact housing for compliant mating with corresponding mating contacts of a mating connector, the electrical contacts including rear-facing retention shoulders that engage the deflectable latches of the finger clips in the corresponding contact cavities to removably secure the electrical contacts in the contact cavities,

wherein the rear-facing shoulder of each electrical contact extends along less than an entirety of a perimeter of the electrical contact, the electrical contacts each including a protrusion extending radially outward from the electrical contact at a location along the perimeter of the electrical contact that is angularly spaced apart from the rear-facing shoulder, the protrusion configured to be received in the notch of the corresponding contact cavity as the electrical contact is received in the contact cavity to ensure that the rear-facing shoulder of the electrical contact is angularly aligned with the deflectable latch of the finger clip in the contact cavity.

12. The cable assembly of claim 11, wherein the electrical contacts include the mating segment, a termination barrel surrounding and mechanically and electrically connecting to an end of an electrical cable that extends from the cable end of the shell, and an intermediate segment between the termination barrel and the mating segment, the intermediate segment defining the rear-facing retention shoulder.

13. The cable assembly of claim 11, wherein the electrical contacts are stamped and formed into a generally cylindrical shape from a sheet of metal, the electrical contacts defining a seam along a length of the electrical contact.

14. The cable assembly of claim 11, wherein the electrical contacts include a termination barrel disposed rearward of the mating segment, the termination barrel surrounding and mechanically and electrically connecting to an end of an electrical cable, the termination barrel including at least one push tab extending radially outward from a cylindrical outer perimeter of the termination barrel, the push tab configured to be engaged by an insertion tool to load the electrical contact into a corresponding one of the contact cavities of the contact housing.

15. The cable assembly of claim 11, wherein the electrical contacts define a depressed region rearward of the mating segment, the deflectable latch of the finger clip within a same contact cavity as the corresponding electrical contact being received in the depressed region, the rear-facing retention shoulder of the electrical contact defining a front of the depressed region, the protrusion of the electrical contact being angularly spaced apart from the depressed region and the rear-facing retention shoulder along the perimeter of the electrical contact.

16. The cable assembly of claim 11, further comprising a grommet held in the chamber of the shell, the grommet composed of a dielectric material and extending between a front end and a rear end, the front end facing the rear end of the contact housing, the grommet defining apertures through the grommet between the front and rear ends that align with the contact cavities of the contact housing, the apertures receiving the electrical contacts therein.

17. The cable assembly of claim 11, wherein the mating segments of the electrical contacts are compliant pins configured for compliant mating with corresponding socket contacts of the mating connector.

18. The cable assembly of claim 11, wherein the contact housing is defined by a front housing and a rear housing that are secured together, the front housing defining the front end of the contact housing and the rear housing defining the rear end, the front and rear housings defining respective front and rear portions of the contact cavities, the finger clips held in the front portions of the contact cavities, the rear portions of the contact cavities having at least one of a smaller cross-sectional size or a different cross-sectional shape than the front portions such that the rear housing blocks the finger clips from moving rearward out of the front portions of the contact cavities.

19. The cable assembly of claim 11, wherein each of the contact cavities of the contact housing has a cross-sectional profile that includes clip region and a reduced diameter region, the contact housing including a ledge at each of two interfaces between the clip region and the reduced diameter region in each contact cavity, the finger clips disposed in the clip regions of the contact cavities and configured to engage the ledges to retain an orientation of the finger clips relative to the contact housing.

20. The cable assembly of claim 19, wherein all of the contact cavities of the contact housing have a common angular orientation relative to the contact housing.

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